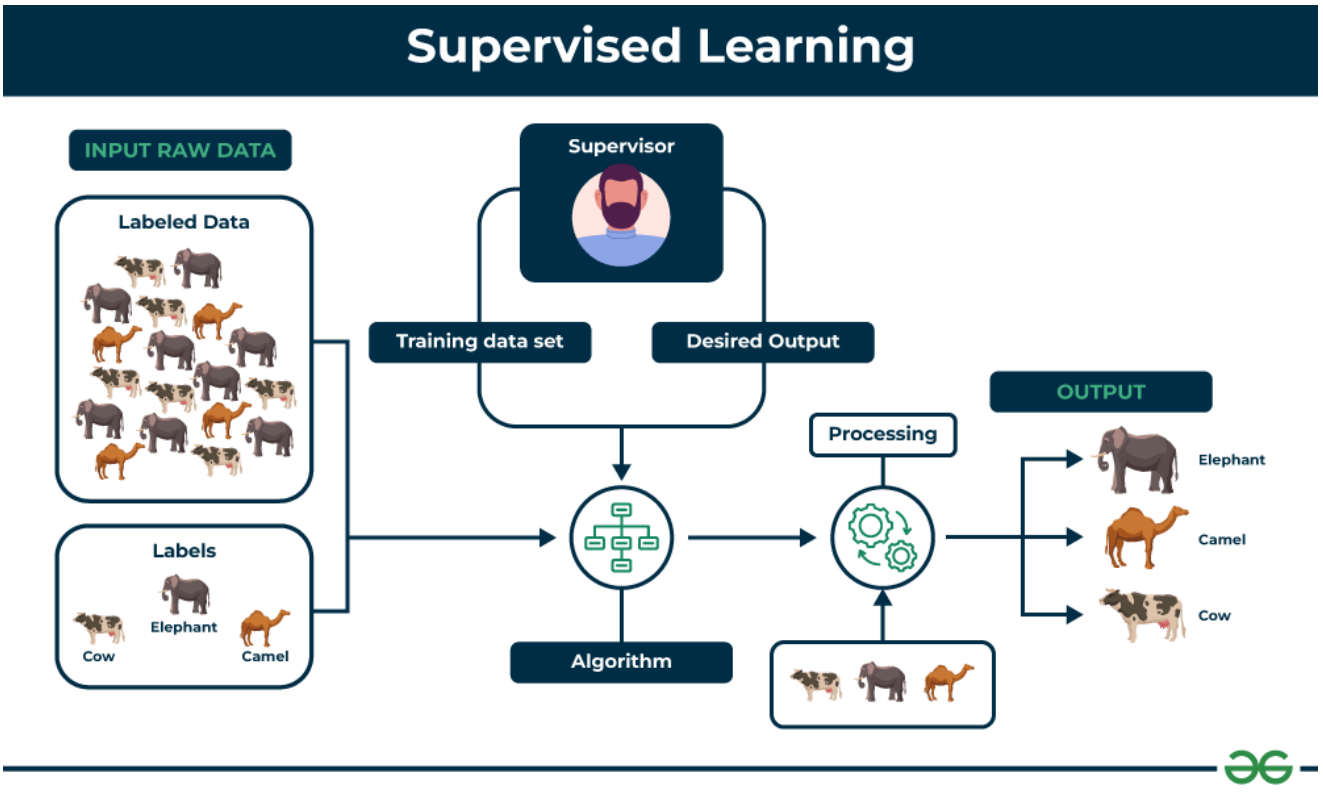
1. Supervised Learning



Supervised learning is a type of machine learning where an algorithm is trained on labeled data. For each training example, the input comes with the correct output.
Goal: Learn a mapping from inputs to outputs so it can predict the output for new, unseen inputs correctly.

In supervised learning, tasks are categorized into two types,

1. Classification tasks
2. Regression tasks

Classification Tasks

This involves predicting categorical labels.
Here, the output variable is a category or a class.

Types of classification tasks,

1. Binary classification: The output has two possible classes.
   Ex:
   Spam detection: Email is either 'spam' or 'not spam'
   Disease diagnosis: Patient is either 'sick' or 'healthy'
2. Multiclass classification
   Ex:

Handwritten digit recognition: 0-9 digits
Animal species identification: Dog, Cat, Rabbit,... etc

3. Multilabel Classification
   Ex:
   Text categorization: A document can be about "Sports", "Politics" and "Technology" at the same time.
   Image tagging: An image can be tagged with "Beach", "Sunset", "Vacation" at the same time.

Evaluation metrics:

- Accuracy
  Measures the proportion of correctly classified instances among the total instances.
  $$\text{Accuracy} = \frac{\text{Number of Correct Predictions}}{\text{Total Number of Predictions}}$$
- Precision(AKA Positive Predictive Value)
  Measures the proportion of true positive predictions among all positive predictions made by the model. It answers the question: "Of all instances predicted as positive, how many were actually positive?"
  $$\text{Precision} = \frac{\text{True Positives}}{\text{True Positives} + \text{False Positives}}$$
- Recall(AKA Sensitivity or True Positive Rate)
  Measures the proportion of true positive predictions among all actual positive instances. It answers the question: "Of all actual positive instances, how many were correctly predicted as positive?"
  $$\text{Recall} = \frac{\text{True Positives}}{\text{True Positives} + \text{False Negatives}}$$
- F1-Score
  Harmonic mean of precision and recall. Useful when you need to find a balance between precision and recall and when the class distribution is imbalanced.
  $$\text{F1-Score} = 2 \times \frac{\text{Precision} \times \text{Recall}}{\text{Precision} + \text{Recall}}$$
- ROC-AUC(Receiver Operating Characteristic - Area Under the Curve)
  A performance measurement for classification problems at various threshold settings. ROC is a probability curve, and AUC represents the degree or measure of separability. It tells how much the model is capable of distinguishing between classes.
  ROC Curve: Plots the True Positive Rate (Recall) against the False Positive Rate (FPR), where FPR is defined as:
  $$\text{False Positive Rate} = \frac{\text{False Positives}}{\text{False Positives} + \text{True Negatives}}$$
  AUC (Area Under the Curve): The area under the ROC curve. The closer the AUC value is to 1, the better the model is at distinguishing between the positive and negative

classes. An AUC of 0.5 indicates no discriminative power, equivalent to random guessing.

> **Note**
>
> **TP**: True Positives (correctly predicted positive instances)
> **FN**: False Negatives (actual positives that were incorrectly predicted as negative)
> **FP**: False Positives (actual negatives that were incorrectly predicted as positive)
> **TN**: True Negatives (correctly predicted negative instances)

Classification Algorithms,

- Logistic Regression
- Decision tree
- Random forest
- Support vector Machines(SVM)
- k-Nearest Neighbours(k-NN)
- Neural Networks(Especially for complex tasks like image and speech recognitions)

Regression Tasks

Involves predicting a continuous value.
Here, the output variable is a real number.

Types of regression tasks,

1. Linear regression: Predict a linear relationship between input variables and the output.
   Ex:
   House price prediction(Predict the house price based on features like size, location and number of rooms)
   Stock price prediction(Predict the future price based on historical prices and other financial indicators)
2. Non-linear regression: Predict a non-linear relationship between input variables and the output.
   Ex:
   Growth rate prediction: Predict a growth rate of a bacterial culture over time.
   Temperature forecasting: Predict the temperature based on time of day, season and other environmental factors.

Evaluation metrics,

- Mean Absolute Error(MAE)

- Mean Squad Error(MSE)
- Root Mean Squared Error(RMSE)
- R-Squared

Regression Algorithms,

- Linear Regression
- Polynomial Regression
- Random Forest
- Support Vector Machines (for regression tasks, also known as SVR)
- Neural Networks (especially for complex, non-linear relationships)